Black silicon solar cells with black bus-bar strings

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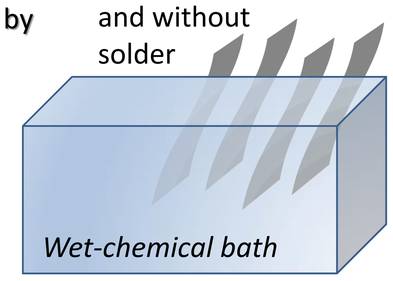
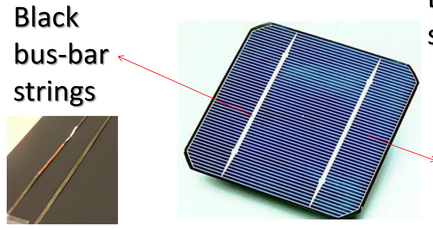
Concept

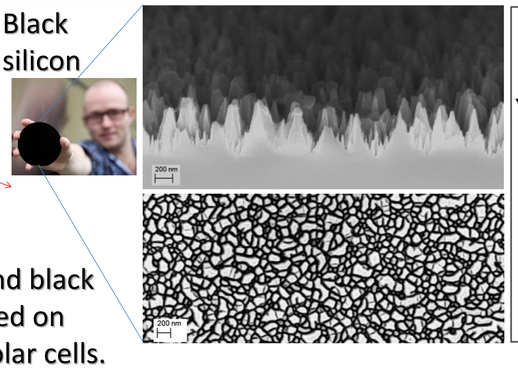
Black bus-bar strings are realized by four different wet-chemical, inorganic surface treatments:

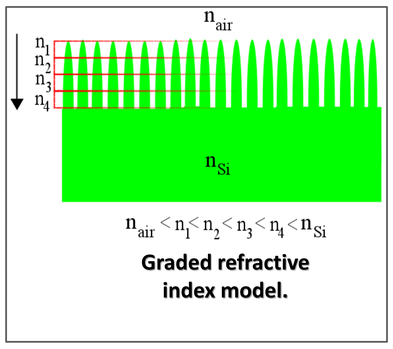
- CuO on Cu without solder
- Etched solder on Cu
- NiZnS on solder
- NiCuCo on solder





Black silicon



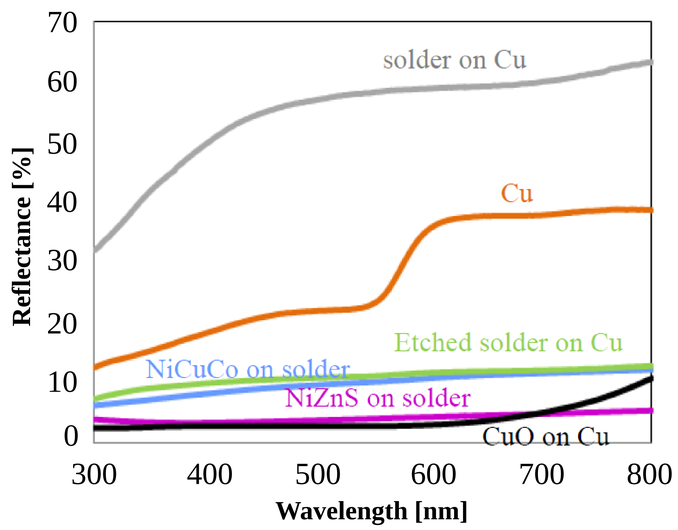


Combining black bus-bar strings and black silicon creates all-black panels based on conventional, front-contacted Si solar cells.

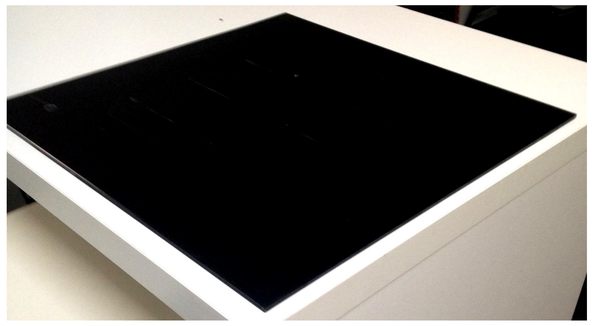
Nanostructures are fabricated by maskless reactive ion etching (RIE) using SF_6 and O_2 plasma.

Reflectance, black bus-bar strings

Measured reflectance as function of wavelength of bus-bar strings without (bare Cu, and Cu with solder) and with (NiCuCo, NiZnS, etched solder and CuO) black coatings.

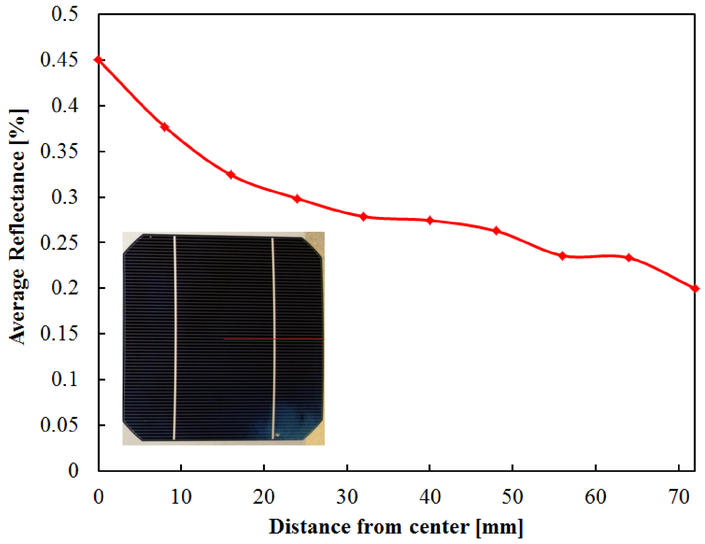


First test panel



Photograph of a 4-cell panel based on screen-printed black Si solar cells and interconnected with black CuO-coated bus-bar strings.

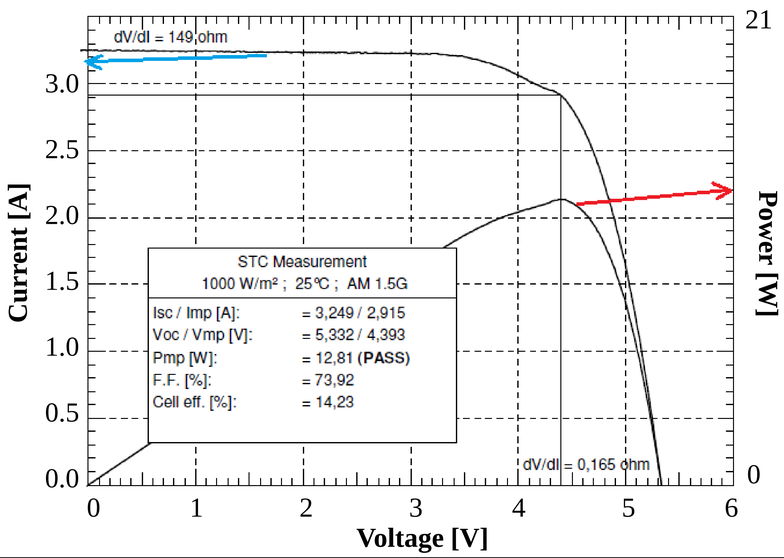
Reflectance, black Si



Measured total (diffuse + specular) reflectance of RIE-textured Si with SiN_x:H averaged over the wavelength range 300-1000 nm as function of the distance from the center of a 156x156 mm² CZ wafer.

CuO + adhesive glue

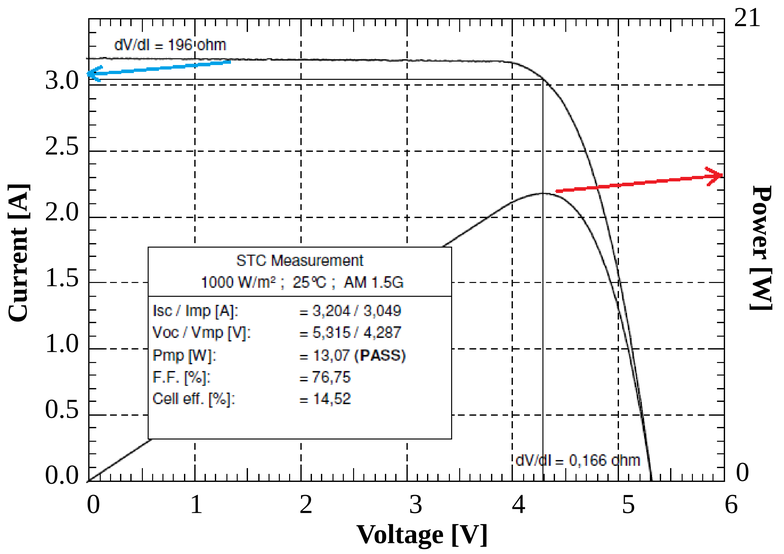
FF ~ 0.74



I-V Results

Current-voltage (I-V) and power measurement of two 9-cell test panels based on 100x100 mm² p-type CZ screen-printed black Si solar cells interconnected with (left) glued CuO coated strings and (right) soldered etched bus-bar strings.

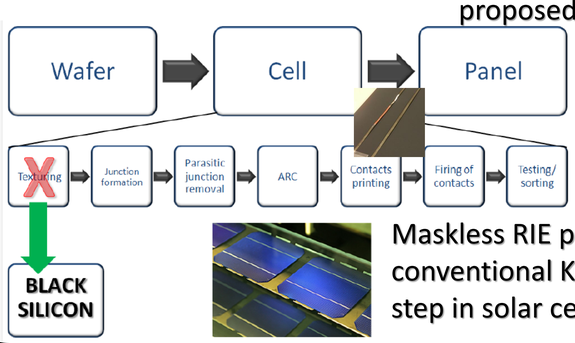
Etched string + soldering



FF ~ 0.77

Industrial Application:

Inorganic, blackened bus-bar strings proposed for interconnection



Maskless RIE proposed as alternative to conventional KOH- and acidic texturing step in solar cell production.

All-black panels from conventional, front-contacted Si solar cells

Conclusion

We present black silicon texturing and blackened bus-bar strings as a potential method for obtaining all-black solar panels. Black silicon results in total, average reflectance below 0.5% in the wavelength range 300-1000 nm across a 156x156 mm² silicon wafer. Black bus-bar strings were realized by various inorganic methods e.g. oxidized copper resulting in reflectance below 3% in the entire visible wavelength range. The combination of these two technologies results in aesthetic, all-black panels based on conventional, front-contacted silicon solar cells without compromising efficiency.